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ABSTRACT

This paper addresses one area of conflict in decisionmaking in computer-based instruction (CBI) research: the relationship between the researcher's definition of CBI either as a medium or as an integrated system and the design of meaningful research questions. (A medium is defined here as a device for the delivery of instruction, while an integrated system incorporates the medium, the learner, the designer, all of the experimental variables, the hardware, the learning environment, and the software, all working together toward the intended outcome of learning.) Through a review of the literature, this paper not only explores the differing definitions of CBI as either a system or a medium, but provides examples of CBI utilized as each. Implications for researchers based on the definition of CBI as a system or a medium are discussed, and guidelines for evaluating current research in the field are provided. (31 references) (Author/BBM)

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CBI: System or Medium?

Abstract

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This paper addresses one area of conflict in decision-making in CBI research: The relationship between the researcher's definition of computer-based instruction (either as a medium or as an integrated system) and the design of meaningful research questions. Through a review of the literature, this paper not only explores the differing definitions of CBI as either a system or a medium but provides examples of CBI utilized as each. Implications for researchers based on the definition of CBI as a system or a medium are discussed, and guidelines in evaluating current research in the field are provided. A list of 31 references is included.

Keywords: computer-based instruction, instructional design, instructional technology, research design, media research.

CBI: System or Medium?

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In 1986 it was estimated that there were more than one million microcomputers in use in elementary and secondary schools in the United States and that this number would increase to approximately 2.8 million in the near future (National Task Force on Educational Technology, 1986). As a result of this microcomputer proliferation in schools there has been a corresponding increase in the quantity of research studying the educational uses and effects on learning of computer-based instruction (CBI). It has been difficult to discern among this wealth of information just what questions constitute meaningful research and how best to approach the research itself. Researchers interested in computer-based instruction come from a variety of disciplines, from instructional design and media instruction to educational psychology and computer science, and, thus, bring different perspectives--indeed, even differing levels of expertise in research methodology to the study of computer-based instruction. The research is still at an adolescent stage of development, with the concomitant conflicts in goal development through which any discipline (or individual for that matter) is obliged to make passage.

One particular area of conflict has been the use of media comparison studies in the study of CBI. According to Salomon and Clark (1977), much of the early research reflects "research with media" as opposed to "research on media". When the research design focuses on the content or methods carried by a medium but not the medium itself, the study represents research with media. For example, to investigate the effects of summary lists on the learning of new information, the textual material and the summary lists could be presented on a computer screen. Discovering that the lists improved students' scores on posttests tells us something about the use of summaries but nothing about the nature of the computer as an instructional message vehicle. If we could compare the results of this study on the computer with the same strategy in textbook format we would expect the same results. Since the same instructional strategy is employed, it requires similar behavior on the part of the learner.

In the relatively uncomplicated study above it is a simple matter to separate media and methods, but in many studies we (or our readers) are unable to do so completely (Hagler & Knowlton, 1987). With highly interactive technologies, media and methods are confounded. For example, interactive video allows immediate review from any point in the lesson. Many computer programs can respond to students' on-task input with corrections and/or prescriptions and remediation. Although less interactive media could incorporate some of these strategies, many of

these strategies are unique to the technologies of instruction for which they were designed and cannot "carry over" to a variety of media. Media researchers are familiar with Clark's (1983) analogy comparing media to delivery trucks and instructional content to the groceries carried by the truck. Clark's contention is that the choice of the truck (medium) is unimportant from a nutritional (achievement) point of view and that, where differences are found in achievement, it is the instructional method used that is responsible for the "superiority" of one medium over another. From this perspective, what is gained from media research is a theoretical understanding of learning in general that is applicable over a wide variety of media. When CBI research is evaluated, therefore, one must determine whether investigators regarded CBI as a medium or as an integrated delivery system.

At this point, the reader could justifiably ask the meaning of these two terms, medium and system. Knowlton (1964) points out that there are two types of definitions, real and nominal. If a "thing" is perceived in much the same way by members of a language group then to define it is but to name it, hence the term "nominal" definition. On the other hand, if a "thing" is perceived differently and understood differently by several members of a language group, giving it a name will not facilitate understanding. A single term for a whole category of widely varying concepts sometimes causes people to believe they are speaking of the same "thing" when this is not the case at all. Knowlton (1964) states that disagreements among members of the same discipline in regard to key terms of the discipline are quite common until the discipline "matures". Such is the state of affairs in our adolescent discipline of computer-based instruction. Real definitions make reference to the criterial attributes of the thing defined, implying some sort of conceptual scheme relevant to our interests. The aim is to achieve a conceptual mechanism to help the researcher avoid the trivial and to ask the incisive question. Salomon (1970) defines an instructional medium as a package of unique modes of presenting information which also fulfill a unique psychological function. According to his definition, if a picture in a book and on a screen fulfill the same psychological function they are one instructional medium (given common learners). Another way Salomon (1970) defines medium is as the overlapping area of two circles: the stimulus-attributes circle and the response circle. When various stimuli have common structural attributes but do not call for common cognitive responses, they cannot be said to constitute one medium. Media were taxonomized according to stimulus attributes for a number of years in instructional technology. One of those who left this approach of classification was Heidt (cited in Cassidy, 1982), who argued for a taxonomy based on learner responses rather than on stimulus characteristics. Heinich, Molenda, & Russell (1982) define 'medium' in a general sense as a means of communication referring to anything that carries information between a source and a receiver.

Once we have arrived at a working definition of the term 'medium', we have to explore the term 'system' for contrast. Romiszowski (1981) contends that the

traditional definitions, such as "a set of components or elements, interacting together towards a common goal", do not provide a fruitful approach. He uses the analogy of a bicycle to illustrate the point that a system exists because someone has defined it as such. The bicycle has clearly defined components--wheels, axle, pedals, chain--and an agreed upon goal or purpose (propelled transport). One might consider the bicycle, however, as only a part of a larger system of urban transport or as a carrier of a smaller system, the gears of the back wheel. Thus, for practical purposes, a system exists because we have drawn the boundaries that limit the extent of the system, defining the components or subsystems that make up the 'system of interest'. We can identify the reason for the existence of the system by examining its relationship to its environment, its inputs and outputs. From this comes the concept of the 'black box', which is analyzed by quantifying the inputs and outputs and, indirectly, the efficiency of the system.

The casual reader might question the importance of these two definitions of 'system' and 'medium', but their importance to the instructional technologist cannot be overestimated. If CBI is a system, it incorporates the medium, the learner, the designer, all the experimental variables, the hardware, the learning environment, the software--all integrated and working together toward the intended outcome: learning. The medium is the delivery device of the system. The true CBI system consists of characteristic strategies that one would normally find from one program to the next, i.e., interactive responding, use of graphics, use of feedback, active learner response, branching capabilities. The computer, while it is a piece of hardware and a medium for instruction, is only part of the system of CBI, a set of components (strategies) defined by the 'system of interest'. Some researchers define the computer as Type 1 technology, or hardware, much the same way one would describe an overhead projector. Indeed, even though they contend that, by itself, the computer is of little value (by implication supporting the systems approach) Hannafin & Peck (1988) refer to computer-assisted instruction as an educational medium throughout their entire text on design. What should make the computer interesting to the researcher, however, are not the attributes of the hardware but the components of the system of which it is an integral part. If CBI is a true system, there are certain types of research questions which become valid and viable for study which would not be otherwise. If CBI is a system then researchers can compare systems, say, CBI to audio-tutorial systems, without the label of "media comparison" studies. Basic research could then address questions regarding theoretical understanding of how systems work to affect learning and motivation, while applied or developmental research could go about the business of improving technology as an educational tool by testing and evaluating theoretical positions.

Clark (1983) argued that media comparison studies did not yield results that suggested media had any influence of learning under any conditions. The major problem Clark addressed in his criticism of these types of studies is the inability of

researchers to control all the confounding variables associated with this type of research. Clark reported the most common sources of confounding in media research seem to be the uncontrolled effect of instructional method or content differences between treatments that are compared and a novelty effect which disappears over time. Ross & Morrison (1988) state that an even more critical concern is whether it is sensible to compare media in the first place since they merely serve as delivery devices, not as the content or the instructional strategy used to teach content. No one challenges Clark's assertion (1983) that, "It seems not to be media but variables such as instructional methods that foster learning." His statement, however, that most computerized instruction is "merely the presentation of PI or PSI via a computer" illustrates a basic misconception that the computer--the hardware-- is the area of interest, not the characteristic strategies employed for each.

Clark (1985) criticized the meta-analysis of 500 studies for classroom-based comparisons of CBI and conventional teaching conducted by Kulik and associates (Kulik, Kulik, & Cohen, 1980). The thrust of Clark's evidence for confounding in these studies was that, on the one hand, methods such as the use of examples and matched non-examples, individualization of pacing, corrective feedback after response, and a close correspondence between instruction and test items tend to be used in the design of CBI lessons but not by teachers in comparison treatments. On the other hand, another source of confounding might be that teachers compete with the computer as a perceived 'rival', thereby diminishing the true effect of CBI on student achievement. In his discussion of the meta-analysis Clark (1985) found serious design flaws in many of the studies which showed positive results with CBI. Much of the argument points toward Clark's perception that the non-CBI treatments were not 'robust'. In studying Clark's review of the meta-analysis, however, this researcher read selected studies from the subset of Clark's reviewed studies and found clear evidence that what was reported as CBI in many studies was simply the employment of the 'hardware' in some fashion. For example, Cox (1974) reported a use of computer-assisted instruction in the use of computer 'simulations' and 'games'. Upon reading the methodology, however, it becomes clear that this was a misuse of the term 'computer-assisted instruction'. The instructor set up simulations of various economic principles, feeding set variables into the computer. Printouts were distributed to the students, who were then told what the printouts were supposed to illustrate. The closest the student came to the computer was handling the paper artifact of the printout. Because this method proved ineffective in teaching economic principles, all CBI systems were predicted to be equally ineffective. While the experiment above is an example of inappropriate research labeled as CBI, there were also included in Clark's (1985) review some particularly well-designed studies employing true CBI, which, incidentally, seemed to also report a higher incidence of achievement. For example, Green & Mink (1973) employed computer assisted simulations of experiments in eyelid conditioning as part of a 2-week component of introductory psychology

compared to two other groups: one group receiving only traditional instructor-led seminars and another group receiving seminars with computer-generated information but not delivered by computer. While none of the groups were able to generalize principles of scientific analysis to other problems, the computer-assisted group performed better on the tasks of labeling variables and controls. The focus of the study by Jones & Sorlie (1976), included in Clark's (1985) review as an experiment utilizing CBI, was on computer-assisted testing. It nevertheless contained information of interest to the designer of CBI. Medical students studying for comprehensive board exams were separated into two groups, one of which had paper and pen testing only and the other with CAT (computer-assisted testing). The CAT group was reported as performing significantly higher on their board exams, attributed by the authors to a cumulative effect of the review process offered by the CAT method. According to Jones & Sorlie (1976) results show that "...the advantage was not due solely to the computer-assisted medium, but to the process made possible by the medium: a 'teaching exam' with interactive review and immediate feedback."

Other studies criticized by Clark (1985) were no more than page-turning uses of the computer (Broh, 1975) or electronic worksheets (McEwen & Robinson, 1976). The most common form of instructional method was some form of drill and practice, a weak use of the CBI format (Suppes & Morningstar, 1969; Chiang, Stauffer, & Cannara, 1978). Another misuse of the term CBI was found in the study of PLAN, a computer-managed program for disadvantaged youth, by Coffman & Olsen (1980). Some of the studies found significant differences favoring a control group (Axeen, 1971) where the same teacher effect might have provided some sort of compensatory rivalry with the computer as teacher, thus confounding the study. Most of these studies, therefore, exhibit design flaws and/or weak uses of CBI, making any generalizations difficult to achieve concerning the efficacy of the CBI system. Clark's contention that the CBI achievement gains were overestimated due to uncontrolled and robust instructional methods embedded in CBI treatments ignores the fact that most of the studies were, indeed, weak uses of a systematic set of strategies inherent in true CBI systems design. If stronger, more effective uses of CBI had been examined, the implication arises that achievement gains would have been more impressive for the CBI groups rather than less so.

As a response to the questions raised concerning the impact media have on learning and media research designs, a continuing debate has been carried out in instructional design journals and at the annual meetings of professional organizations in the field. Simonson (1987) led a symposium on the status of research in instructional technology which brought together researchers advocating extreme positions in the debate. In the first of four papers presented in the symposium, Clark (1987) maintains his original position that media have no impact on learning. He also takes the position that media attribute studies are not supported by findings in cognitive research. He suggests that more profitable studies in media research would

result from abandoning the older "craft" approach to media in favor of a newer scientifically-based technology approach and argues for a renewed commitment to and training in research methodology.

Kulik and Kulik (1987), in the second symposium paper, present results of four separate statistical analyses of findings on computer-based instruction which indicate that computer-based instruction does indeed have positive effects on students. The authors discuss three factors which might have contributed to favorable reports in the literature: editorial gatekeeping, experimental design flaws, and instructional quality. They suggest that research continue, focusing on different research designs to investigate reasons for differences.

In the third of the symposium papers, Tennyson (1987) elaborates on the basic question of the efficacy of media in improving learning. According to the author, the problem is not the technology, but, rather, the failure of proponents to adequately trace the variables of their respective media techniques to clearly defined learning processes. He argues that, if instructional methods and/or media are to improve learning, they must have a direct trace to a specific learning process and empirical support demonstrating their significance. Focusing on the tracing process, Tennyson presents an information processing model of learning as a means by which researchers may determine if specific media variables and methods may improve learning. Secondly, he maintains that media "...is but one component in a complex instructional system. A system that involves principles of instructional design as well as methods of instructional delivery" (p.8).

Winn (1987) concluded the symposium by identifying five aspects of media that might affect learning: 1) the technology used; 2) the symbol systems employed; 3) the content conveyed; 4) the setting in which media are employed; and 5) thoroughness of message design. Since Clark's (1983) argument against media studies deals only with the technology for delivery of instruction, Winn examines the other four factors might affect learning, including how these factors relate to technology.

Although the symposium is of interest to all media researchers, the debate continues over what constitutes meaningful research of media variables. Simonson's (1987) hope that the papers and discussions presented would help "clear the air" on this issue may not have been realized, but they may serve, nevertheless, as guides along the paths toward meaningful media research.

Summary

If CBI is defined as merely a medium, the nature of legitimate research becomes limited, perhaps only to those designs which ask questions concerning strategies of instruction. Failure to limit research to these legitimate questions gives rise to the media comparison studies which characterized early media research. According to Salomon and Clark (1977), much of this early research reflects "research with media" as opposed to "research on media". Unfortunately, even a cursory review of current literature reveals that many modern research designs focus on the content or methods *carried* by a medium but not the medium itself. These studies represent research with media.

If CBI is a system, it incorporates the medium, the learner, the designer, the hardware, the learning environment, the software (including the displays, user input, and program decisions). These factors are all integrated and work together toward the intended outcome: learning. *The medium becomes the delivery device of the system.* The true CBI system consists of characteristic strategies that one would normally find from one program to the next, i.e., interactive responding, use of graphics, use of feedback, active learner response, branching capabilities.

The computer, on the other hand, is a piece of hardware and a medium for instruction, only part of the system of components (strategies) defined by the "system of interest"—CBI. Some researchers (Heinich, Molenda, & Russell, 1988; Davies, 1971; Lumsdaine, 1964) define the computer as Type 1 technology, or hardware, much the same way one would describe an overhead projector. What should make the computer interesting to the researcher, however, are not the attributes of the hardware but the components of the system of which it is an integral part. If CBI is a true system, there are certain types of research questions which become valid for study which would not be otherwise. If CBI is a system then researchers can compare systems, e.g., CBI to audio-tutorial systems, without the label of "media comparison" studies. Basic research could then address questions regarding theoretical understanding of how these systems work to affect learning and motivation, while applied or developmental research could go about the business of improving technology as an educational tool by testing and evaluating theoretical positions. When CBI research is evaluated, therefore, one must determine whether investigators regarded CBI as a **medium** or as an **integrated delivery system** that *fully* utilizes the attributes of the computer to enhance the delivery of the instruction.

If CBI is no more than a delivery vehicle as Clark's grocery truck analogy maintains, with no effect on the analogous nutritional (learning) requirements of the consumer, then CBI is just another piece of fancy hardware with no inherent, embedded strategies at work. As Morrison, Ross, & O'Dell (1988) have asserted, however, the delivery truck is defined many times by the attributes (e.g., refrigeration

units) which insure that the groceries delivered are in peak condition. By extension of the analogy of the grocery truck one can begin looking at the entire system of suppliers to the consumer. The dairy operation, for example, is not defined only by the cows in the pasture nor is it limited to the refrigerated trucks which deliver the milk. It is, however, an integrated system working together to achieve its particular goal of milk supply. One can find fault in the taste of the milk but cannot attribute that fault to the system itself, rather to a fault in one part of the system, whether it is a breakdown in the refrigeration unit or inadequate feed for the cow.

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